REMARKS

Enclosed herewith is a Substitute Specification in which the specification as filed has been amended in various places to correct typographical and grammatical errors, and also to add section headings.

In support of the above, enclosed herewith is a copy of the specification as filed marked up with the above changes.

The undersigned attorney asserts that no new matter has been incorporated into the Substitute Specification.

The Examiner has indicated that the certified copy of EP99204539.3 was not filed. Applicant submits that the Examiner is mistaken. In particular, enclosed herewith is a copy of the Transmittal Letter for this application in which it is checked "Certified copy of EUROPEAN application Serial No.99204539.3" is enclosed. Furthermore, enclosed herewith is a copy of Applicant's Postcard receipt indicating that the Certified Copy was indeed received by the USPTO.

Applicant therefore respectfully requests acknowledgment of the receipt of the certified copy of EP99204539.3.

The claims have been amended to more clearly define the invention as disclosed in the written description. In particular, mis-numbered claims 2-8 have been renumbered as claims 2-9 as suggested by the Examiner. In addition, claims 1 and 2 has been cancelled and are replaced by new claims 10 and 11. In addition,

claim 9 has been cancelled. In addition, claims 3 and 5-7 have been amended such that they now depend from new claim 10. Finally, the claims have been amended for clarity.

Applicant believes that the above changes answer the Examiner's 35 U.S.C. 112, paragraph 2, objections to the specification and rejection of the claims, and respectfully requests withdrawal thereof.

The Examiner has rejected claims 1-3 and 6 under 35 U.S.C. 102(e) as being anticipated by Japanese Patent Reference JP11032397 to Emura Akira (Akira). The Examiner has further rejected claims 4 and 5 under 35 U.S.C. 103(a) as being unpatentable over Akira in view of U.S. Patent 3,962,543 to Blauert et al. Finally, the Examiner has rejected claims 7 and 8 under 35 U.S.C. 103(a) as being unpatentable over Akira in view of European Patent Application No. EP0661906A1.

Applicant first would like to note that an analysis of the differences and similarities between the invention and Akira is only then possible if the content and meaning of Akira is known. Applicant was not able, from the Abstract and the figures, to truly understand the content and meaning of Akira.

To that end, Applicant has had prepared and files herewith a computer translation (i.e., the translation as can be obtained from the site of the Japanese Patent Office) of Akira including figures. However, even with the computer translation, Applicant

found it difficult, if not near impossible, to truly understand the content and meaning of Akira.

Therefore, Applicant has had prepared and files herewith a manual translation (i.e., done by a human translator) of the major portion (paragraphs [0007] to [0026], and including the figures) of Akira.

Paragraph [0009] of Akira describes the technical problem that Akira seeks to overcome. The system to which Akira is directed comprises headphones (11L and 11R) to which a signal is sent and, at the same time as the listener hears the sound emanating from the headphone, a loudspeaker (12) is also in operation. The headphones and loudspeaker are thus jointly used. This situation is not uncommon. The person wearing the headphones, however, does not just hear the sound emanating from the headphones (11L and 11R), but also sound from the loudspeaker (12). For this person, the sound from the loudspeaker could be considered, and in fact is, "noise". The object of Akira is to effectively remove this "noise" from the sound heard by the person wearing the headphones.

To do so, in Akira, the "noise" is recognized and isolated as follows: suppose that there is a signal $S_{at\ headphone11L}$ going to the headphone (for instance headphone 11L). The signal at the microphone 13L, however, will not be the signal $S_{at\ headphone11L}$ but will be modulated by the transfer function

$h_{transfer\ headphone11L-microphone13L}$ between headphone 11L and microphone 13L, i.e., $S_{at\ headphone\ 11L} \cdot h_{transfer\ headphone11L-microphone13L}$. Thus, if the signal would be directly sent to the headphone 11L, the sound perceived at the left ear would thus always be wrong, since the transfer function headphone-microphone would not have been taken into account. In order to make sure that the signal at the microphone is the "correct" signal, the signal coming from block 23L is first multiplied, at filter 14L placed before the headphone 11L, by the inverse h^{-1} of the transfer function $h_{transfer\ headphone11L-microphone\ 13L}$. The signal $S_{incoming}$ (signal from 23L) coming into the filter 14L is thus multiplied by $h^{-1}_{transfer\ headphone11L-microphone13L}$, before going into headphone 11L and multiplied with $h_{transfer\ headphone11L-microphone13L}$ between headphone 11L and microphone 13L. The total signal at the microphone $S_{microphone}$ is then $S_{incoming} \cdot h^{-1}_{transfer\ headphone11L-microphone13L} \cdot h_{transfer\ headphone11L-microphone13L} =$ Sincoming. Thus, at least in theory, it is ensured that the signal at the microphone is the same as the intended signal. However, due to the fact that the loudspeaker 12 is also operative (loudspeaker and headphones are jointly used) the signal at the microphone will not be solely the incoming signal but $S_{microphone}$ is $S_{incoming} \cdot h^{-1}_{transfer\ headphone11L-microphone13L} \cdot h_{transfer\ headphone11L-microphone13L}$ + signal from loudspeaker at microphone = $S_{incoming}$ + signal from loudspeaker at microphone 13L = $S_{incoming}$ + "noise".

The task that is set to be resolved in Akira is to remove this "noise". Once the noise is removed, the signal at the ear is a "clean" signal. The "noise" is, in fact, the signal $S_{loudspeaker}$ of the loudspeaker 12 times the transfer function h_L between loudspeaker 12 and microphone 13L, i.e., the signal from loudspeaker at microphone = $h_L \cdot S_{loudspeaker}$. The first task is to isolate the "noise" signal $h_L \cdot S_{loudspeaker}$ from the microphone signal. In Akira, this task is accomplished by, on the one hand, delaying the incoming signal via delay 16L (to take into account the fact that there is a slight time delay between the original signal and the microphone signal), and, on the other hand, subtracting this delayed signal from the microphone signal in subtractor 15L. The signal after said subtraction is ideally $S_{microphone} - S_{incoming} = S_{incoming} \cdot h^{-1}_{transfer\ headphone11L-microphone13L} \cdot h_{transfer\ headphone11L-microphone13L} + h_L \cdot S_{loudspeaker} - S_{incoming} = h_L \cdot S_{loudspeaker}$. This isolates the "noise" from the wanted signal. If one is to add to the incoming signal, a signal of the same amplitude and of opposite sign as the "noise", i.e., a signal $-h_L \cdot S_{loudspeaker}$, the "noise" due to the loudspeaker is counteracted and the listener would only hear the intended signal. This is exactly what is done in Akira. The signal 27L from the loudspeaker is delayed (to take into account time delay, comparable to what is done in delay 16L) and convolved with a filter function h^*_L in adaptive filter 24L. This signal $h^*_L \cdot S_{loudspeaker}$ is then subtracted from the "noise signal" $h_L \cdot S_{loudspeaker}$ in subtractor 26L. The adaptive

filter is adjusted until the error signal is zero, i.e., until $h^*_L S_{loudspeaker} = h_L \cdot S_{loudspeaker}$, i.e., $h^*_L = h_L$. The signal before delay 16L and filter 14L is then $S_{true} - h_L S_{loudspeaker}$, where S_{true} is the "true sound" as would be presented to the left ear when only the headphone is operative.

It is then possible to calculate the signal at the microphone 13L (which stands for the sound as heard in the left ear), using filter 14L, headphone 11L, as a function of the signal S_{true}, and the loudspeaker signal $S_{loudspeaker}$:

a. $S_{microphone} = S_{incoming} \cdot h^{-1}_{transfer\ headphone11L-microphone13L} \cdot h_{transfer\ headphone11L-microphone13L} + h_L \cdot S_{loudspeaker}$, giving

b. $S_{microphone} = S_{incoming} + h_L \cdot S_{loudspeaker} = S_{true} - h_L \cdot S_{loudspeaker} + h_L \cdot S_{loudspeaker} = S_{true}$, and consequently (since $S_{microphone} = S_{true}$), the listener hears the same sound in the left ear, as would be present if the loudspeaker 12 would not be present. This is exactly what is described in paragraph [0012]. See the part of paragraph [0012] which reads "consequently, in the left ear, the same sound as in the case wherein the sound is only presented from the headphone, is presented". The "noise" on the left ear due to the loudspeaker, when jointly using (see paragraph [0007]) the headphones and the loudspeaker, is removed so that a "clear signal" remains.

As such, the known system of Akira is based on a number of elements, a fixed headphone to microphone transfer function

$h_{transfer\ headphone11L-microphone13L}$ at filter 14L, an adaptive filter 24L to calculate h_L, a number of cascaded subtractions (subtractors 15L, 26L) and a number of signal manipulations in order to remove the "noise" on the signal in the ear due to the loudspeaker 12, when using, jointly, a loudspeaker and headphones. It is a rather complicated system.

Apart from its complexity, the known system ideally does the following (as is clearly stated in paragraph 12): it removes the "noise" due to the loudspeaker, so that the perceived sound is the same as if the signal would only be present on the headphone. Assuming this to be the case, ideally the sound in the ear would thus be the same as if there would be no signal on the loudspeaker. If there is no signal on the loudspeaker, the system operates very simply, since we may remove all elements that are then inoperative, and only filter 14L, headphone 11L and microphone 13L are active. The signal at the microphone 13L is $S_{incoming} \cdot h^{-1}_{transfer\ headphone11L-microphone13L} \cdot h_{transfer\ headphone11L-microphone13L} = S_{incoming}$. This formula, however, denotes the ideal situation. In reality, the two transfer functions are not, and cannot be, each others exact inverse. The filter function of filter 14L, i.e., $h^{-1}_{transfer\ headphone11L-microphone13L}$ is a fixed function as can be clearly seen in Figure 1, independent of the actual head upon which the headphones are placed, and thus, must be some average, whereas the transfer function between headphone and microphone $h_{transfer\ headphone11L-microphone13L}$ is a real-life function

dependent on the head size and form. This known system, thus, is incapable of taking into account differences in the individual transfer function. The differences in transfer function are, however, considerable. To some extent, the known system can remove "noise" from a loudspeaker when a loudspeaker and headphones are used jointly, independent of the transfer function h_L. However, it has no means to take into account the individual nature of transfer functions $h_{loudspeaker-ear}$. Any deviation between the perceived sound on the left (right) ear and the intended sound, which is present due to this effect, will stay present, for the simple reason that that is how the system operates, the "noise" is removed, nothing more, nothing less. Given the fact that a fixed inverse transfer function, i.e., some average value for the transfer function, is used to be multiplied by an individual head-ear transfer function, the net result will be that the same incoming signal will be heard differently by different persons.

In the subject invention, as explained in the Substitute Specification (see page 2, paragraph [0006], lines 22-24), the transfer function (HTRF) is a strongly individual and important one which can only be approximately estimated by a fixed function. In the present invention, these individual transfer functions (see Figures 2 and 5 of the application) are called W_{ll} (for the transfer function from left headphone to left ear), W_{rr} (for the transfer function from the right headphone to the right ear), etc. The

transfer function from a loudspeaker to the left ear (comparable to h_L in Akira) is called W_{pl}. In the present invention, the object is not the remove "noise" from a loudspeaker that is jointly used, but to establish a system that is capable of accurately producing sound even given the fact that HTRF functions are highly individual, and to do so with a relatively simple design.

The crux of the present invention is the following (with reference to Figure 2 and parts of the specification):

A signal is sent to the loudspeaker, and simultaneously the signal on the microphone $r_1(k)$ is measured. The total transfer function between loudspeaker and the microphone is initially unknown. While the loudspeaker is playing, the signal to the headphone 4 is filtered with a variable filter function W_{XL} such that, in the end, the signal $r_1(k)$ on the microphone is zero. Thus the microphone signal itself is taken as an error signal to establish a filter function (see claim 1, "means coupled to receive said resultant signal for adjusting said modifying means so that said resultant signal is substantially zero"). This situation, i.e., the microphone signal is zero, occurs when, and only when, the signal on the headphone 4 is such that it establishes a sound signal pressure at the position of the microphone which is the exact same signal but with opposite sign of the signal produced by the loudspeaker PL. When this situation is established, the filter functions W_{XL} are recorded, e.g., stored in computer memory. Then,

when the loudspeaker signal is removed, the signal from the headphone 4 comprises the exact same information as that due to the loudspeaker. Thus the listener hears exactly (within the accuracy of the system) what he/she heard when the loudspeaker was on, irrespective of individual transfer functions. This is accomplished via the adaptive cycle as shown in Figure 2, i.e., W_{XL} is adapted until the microphone signal rl(k) is zero. Only one (1) function W_{XL} is determined by this single adaptive cycle. This function W_{XL} is, as explained, for instance, in the Substitute Specification on page 13, lines 22-24, the same as W_{pl}/W_{11} , and is, in the invention, determined as a single function obtained in a single step, not obtained by two separate determinations of W_{PL} and W_{11}, and is correct for every individual. The function W_{PL}/W_{11} is not some average, but the true individual transfer function. This gives reliable results for each person, irrespective of the size and shape of the head and all other factors (see page 13, line 10-14 of the Substitute Specification). The established transfer function W_{XL} is then used for other signals, i.e., when the headphone is used, without the use of a loudspeaker, to simulate (external sound simulation) that the sound is coming from said loudspeaker. In a very simple manner, an accurate result is obtained.

Comparing the inventive system to the system of Akira, the differences become clear, in Akira, a more complicated system is used, and only the function h_L (comparable to W_{PL}) is adaptively

determined. The transfer function in filter 14L is some fixed average. Thus, it is not possible to give reliable results for every person irrespective of the size and shape of the head and other factors, due to the fact that the transfer function in 14L is fixed. In the inventive system, a much simpler system is given, which is capable of giving reliable results for every person. So, compared to the known system, a simplification is achieved, as well as a major improvement in quality. As explained above, this is not possible with the system as known from Akira, due to the fact that the filter 14L is fixed. A person faced with said problem, if he would realize the problem, which he could not do on the basis of Akira alone, could contemplate to use somehow an adaptive filter 14L. How such adaptation would have to be realized is unclear from Akira, but one thing is certain, this will result in a further complication of the already complicated design of Akira, i.e., only increasing the already large difference in complexity between the system of Akira and the system in accordance with the invention. The net result would be two adaptive cycles giving two adaptive filter functions. Even if this would be accomplished, the net result will most probably be worse than that of the present invention, since two adaptive cycles would have to be used, and usually, the total error of two cycles is larger than for one, i.e., a larger inaccuracy (as compared to the present invention) would result. This may be particularly important since inverse

functions are used in Akira, namely h^{-1} in filter 14L. In practice, such functions often may become unstable and/or wildly fluctuate and, as a result, large errors in the $h^{-1}h$ function result. In the system and method of the subject invention, this problem does not occur, since only one function W_{XL} is determined, which may be zero without any problems. It is important to realize that the inventors have thus chosen a different path from the one shown and/or suggested in Akira, which leads to an improvement in sound reproduction as well as a simplification of the design compared to content of Akira.

In summary, Akira aims to eliminate the contributions of a loudspeaker to the sound heard by a person wearing headphones when the loudspeaker is operating, while the subject invention aims to simulate a phantom loudspeaker in the position of an actual loudspeaker in the sound heard by a person wearing headphones <u>without the actual loudspeaker operating</u>.

The Blauert et al. patent discloses a method and arrangement for controlling acoustical output of earphones in response to rotation of listener's head in which, as noted by the Examiner, probe tube microphones are arranged for insertion into the ear of a listener, and in which, arguably, the earphones equipped with the probe tube microphones may be inserted into the ear of the listener.

Applicant submits, however, that Blauert et al. does not supply that which is missing from Akira, i.e., a system for simulating a phantom loudspeaker in the position of an actual loudspeaker in the sound heard by a person wearing headphones without the actual loudspeaker operating.

The Inanaga et al. patent discloses a headphone device which, as noted by the Examiner, includes sensors for detecting information in respect to the turning movement of a listener's head in the direction in which the signal is perceived by the listener, which provides means of determining the position of the headphones worn by the listener and the sound sources, and determining localization.

Applicant submits, however, that Inanaga et al. does not supply that which is missing from Akira, i.e., a system for simulating a phantom loudspeaker in the position of an actual loudspeaker in the sound heard by a person wearing headphones without the actual loudspeaker operating.

In view of the above, Applicant believes that the subject invention, as claimed, is neither anticipated nor rendered obvious by the prior art, either individually or collectively, and as such, is patentable thereover.

Applicant believes that this application, containing claims 3-8, 10 and 11, is now in condition for allowance, and such action is respectfully requested.

Respectfully submitted,

By

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By Burnett James